Materials Research Proceedings **23** (2022) 76-82 https://doi.org/10.21741/9781644901953-10

Mechanical Properties of Fiber Reinforced Concrete by using Sisal Fiber with M-Sand as Fine Aggregate

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Keywords: Sisal Fiber, Mechanical Properties, Sisal Strands

Abstract. Conventional concrete has a low tensile strength, constrained ductility and little protection from crack propagation. The inward miniaturized scale of cracks, prompting weak disappointment of concrete. Investigations have been carried out in many countries on various mechanical properties, physical performance and durability of cement-based matrices reinforced with naturally occurring fibers including sisal, coconut, jute, bamboo, and wood fibers. Raised natural mindfulness and an expanding worry with an unnatural weather change have invigorated the search for materials that can supplant traditional engineered fiber. Characteristic fiber, for example, sisal strands show up as one of the great options since they are accessible in sinewy structure and can be separated from plant leaves, stalk, and products of the soil at exceptionally low expenses. In this work, the impact of sisal strands on the quality of cement for M25 evaluation has been examined by shifting the level of filaments in concrete. Fiber substance were shifted by 0.05%, 0.10%, 0.15%, 0.20%, 0.25%, 0.30%, 0.35% and 0.40% by volume of cement. Cubes, Cylinder and Prism were cast to assess the Compressive, Split Tensile and Flexural Strength test. Every one of the samples was tested for a time of 28 days curing. The results of fiber reinforced concrete for 28 days curing with a varied percentage of fiber were studied and it has been found that there is significant strength improvement with addition of sisal fiber in concrete.

Introduction

Concrete is weak in tension and has a brittle character. The concept of using fibre to improve the characteristics of construction materials is practiced from olden days. The quality of concrete is determined by its mechanical properties as well as its ability to resist deterioration. The strength of the concrete is most important characteristics, as it has strong relationship with quality. Also the stress-strain behaviour of concrete depends upon the properties of the material with which the concrete is made and the loading parameters.

Fibre Reinforced Concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibre that are uniformly distributed and randomly oriented. Fibre include steel fibre, glass fibre, synthetic fibre and natural fibre. The use of various fibre which lead varying properties to the concrete. In addition, the character of fibre reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities

Sisal fibre is derived from the leaves of the plant. It is usually obtained by machine decortications in which the leaf is crushed between rollers and then mechanically scraped. The fibre is then washed and dried by mechanical or natural means. The dried fibre represents only

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4% of the total weight of the leaf. Once it is dried the fibre is mechanically double brushed. Fibre is subsequently cleaned by brushing. Dry Fibre are machine combed and sorted into various grades, largely on the basis of the previous in-field separation of leaves into size groups. Mathur (2005) were studied on the building materials such as laminates/panels, doors, roofing sheets, shuttering and dough moulding compound prepared by using natural fibre composites. In this study, the deflection in the plate was 1.95 mm at upon initial loading and 2.57mm after 7 days. This shows good improvement than jute fibres.

Flavio et al.,(2009) investigated the Cracking mechanisms in durable sisal fibre reinforced cement composites. In this paper the sisal fibre with 3% reinforcement as used. A matrix with partial cement replacement by 30% of metakaolin and 20% of calcined waste crushed clay brick was used in order to improve the durability aspects. The post crack modulus decreases at the range compared to the elastic response, and the cracks are arrested within the tensile region which leads to high mechanical performance and energy absorption capacity. Funga (2009) experimented an investigation on the processing of sisal fibre reinforced polypropylene composites. In this paper, a pre-impregnation technique has been introduced for the injection moulding of sisal fibre reinforced polypropylene (PP/SF) composites. Young's modulus by about150%, and the tensile strength was increased by about 10%. Specimens injection moulded using this temperature profile will be called HT (for high temperature) specimens. The reinforcement efficiency for LT specimens is slightly higher than HT samples. Romildo et.al.,(2010) experimented the Physical and mechanical properties of durable sisal fibre cement composites.

The ultimate bending in hot-water immersion is 3.8 times higher and the toughness 42.4 times higher than pc composites. Reis(2012) reported that the fracture mechanics approach of Sisal fibre polymer mortar composites. In this paper, the untreated sisal Fibre and with different surface treatment as reinforcing agent in polymer mortars were made and its fracture propertieswere calculated. Untreated and surface treated sisal Fibre when used as reinforcement contributes significantly to improve the fracture properties both energy and toughness of epoxyand unsaturated polyester polymer mortars.

Materials and methodology

In the present study, sisal fibres were obtained from the Tokyo fibres, Ltd, Coimbatore, India. The fibre were chopped in to 12mm size with a diameter of 300μm.

Cement: Ordinary Portland cement (OPC 53) grade conforming to IS 12269-1987 was used.The specific gravity of cement is 3.115.

Fine Aggregate: River sand was as fine aggregate in the study. It was properly graded to give the minimum voids ratio and shall be free from deleterious materials like clay, silt content and chloride contamination.

Table 1. Properties of river sand

Test for Fine Aggregate	Relevant Code	Results
Specific gravity	IS:2386 -1963 (Part I)	2.65
Bulk density	IS:2386 -1963 (Part III)	1721.32 kg/m^3
Fineness Modulus	IS:383-1970	2.39

Sisal fiber: Sisal fibre is one of the most widely used natural fibres and is very easily cultivated. It has short renewal times and grows wild in the hedges of fields and railway tracks. Nearly 4.5 million tons of sisal fibre is produced every year throughout the world. Tanzania and Brazil are the two main producing countries. Sisal fibre is a hard fibre extracted from the leaves of the sisal plant (Agave sisalana). Though native to tropical and sub-tropical North and South America, sisal plant is now widely grown in tropical countries of Africa, the West Indies and the Far East. Sisal fibres are extracted from the leaves. A sisal plant produces about 200±250 leaves and each leaf contains 1000±1200 fibre bundles which are composed of 4% fibre, 0.75% cuticle, 8%dry matter and 87.25% water. So normally a leaf weighing about 600 g will yield about 3% by weight of fibre with each leaf containing about 1000 fibres.

Table 2 . Chemical Composition of Sisal Fibre

Parameter		Percentage
Cellulose		65%
Hemicelluloses		12%
Lignin		9.9%
Waxes		2%
Total		100%

Casting and Curing of fibre reinforced concrete

In this work, the cube, cylinder and prism were casted with and without addition of fibres. The fibres percentages are added by volume of concrete. Each three specimens were casted for various fibre percentage added in concrete. The beams are casted for optimum percentage based on the test results from various fibre percentage. The casted specimens were demoulded on the next day and kept in water for 28 days.

Testing for fresh and hardened concrete

The fresh and hardened concrete with and without sisal fibre were tested by various methods in the following.

Slump cone test

The concrete slump test is an empirical test that measures the workability of fresh concrete. It measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete.

Compaction factor test

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus.

Table 3. Slump and Compaction Value

S.No	Mix Identification Fibre%	Slump value (mm)	Compaction factorvalue
1	0	72	0.80
2	0.05	70	0.82
3	0.10	70	0.82
4	0.15	70	0.82
5	0.20	68	0.82
6	0.25	68	0.82

Materials Research Proceedings **23** (2022) 76-82 https://doi.org/10.21741/9781644901953-10

Compressive strength test
The test was conducted as per IS 516-1959. The cubes of standard size 150 X 150mm X 150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of CTM, of capacity 200 tones without eccentricity and a uniform rate of loading of 140 kg/cm per minute was applied till the failure of the cube. The Compressive strength test is shown in Fig-1

Split tensile strength test
This test was conducted ad per 5816-1970. The cylinders of standard size 150mm diameter and 300mm height was placed on the CTM with capacity 200tonnes, with the diameter horizontal. At the top and bottom two strips of wood where placed to avoid the crushing of concrete specimen at the points where the bearing surface of the compression testing machine and the cylinder meets. The Split tensile strength test is shown in Fig-2.

Flexural strength test
SFRC beams of size 100 X 100 X 500mm were tested using a servo controlled UTM as per the procedure given in ASTM-78.

Results and discussions
Test results of compressive strength, split tensile strength, flexural strength test.

Compressive strength
Irrespective of type of mix, all the specimens showed increased compression values as age of concrete increases and maximum values are reported for 28 days aging. In all curing ages, the maximum compressive strength is achieved for M3 specimens and this increase is almost 16.5% and 13% greater than that of reference specimen and sisal reinforced specimen without polymer. Also, it is noted that M1 specimen shows greater strength next to M3, which expresses the superior performance of latex in terms compressive strength than specimens prepared without latex addition. Moreover, the strength attainment of latex polymer modified concrete was found to be quick when compared with concrete without latex. Thus from the results, it is noticed that the 28 days compressive strengths of latex concrete ranges from 1.15-1.19 times and concrete without latex is 1.85-1.96 times that of 7 days strength. Therefore, reference concrete and sisal fibre concrete modified with latex polymer is suitable for repair works and other works which requires earlier strength attainment.

Split tensile strength
As that of compressive strength, split tensile strength also increases with increase of age of specimens. Also, the entire specimen shows greater strength when compared with reference specimen irrespective of the ages of concrete. From that, the concrete prepared with latex and sisal presented the maximum split tensile strength and the improvement of strength of 28 days specimens are compared and is almost 36% higher than that of reference specimen (M0) and 15.5% than unmodified sisal fibre concrete (M2). Also the concrete modified with latex (M1) shows strength increment upto 13% than M0 but 4% decrement than sisal fibre concrete (M2). Inall respects, sisal fibre reinforced concrete with and without latex shows better performance under split tensile test.

Flexural strength
Under all ages of curing, concrete specimens offered maximum strength for specimens prepared with latex and sisal fibre. Also, as in previous cases, increase of flexural strength is observed with increase of curing period. The maximum strength attainment is achieved by M3 specimens

under all curing ages and the 28 days cured specimens are compared here. Therefore, the M3 concrete showed 28% and 12% higher strength than the reference and M2 concrete specimens. The strength variation under flexure follows the same trend as in case of split tensile strength. Next to M3 concrete M2 shows better performance and is almost 15% and 2% greater than M0 and M1 respectively. From this, it is evident that the incorporation of sisal fibre imparts greater strength under flexural loading.

Table 4 : Strength Results

Mix ID	**Compressive strength (N/mm^2)**			**Split tensile strength (N/mm^2)**			**Flexural strength (N/mm^2)**		
	7 days	14 days	28 days	7 days	14 days	28 days	7 days	14 days	28 days
M0	21.76	37.62	42.70	2.19	2.44	2.63	4.36	5.06	5.12
M1	38.5	41.71	45.96	2.34	2.68	2.98	4.91	5.23	5.77
M2	23.08	39.19	44.14	2.78	3.07	3.10	5.29	5.62	5.88
M3	43.15	46.99	49.74	2.97	3.27	3.58	5.72	5.88	6.56

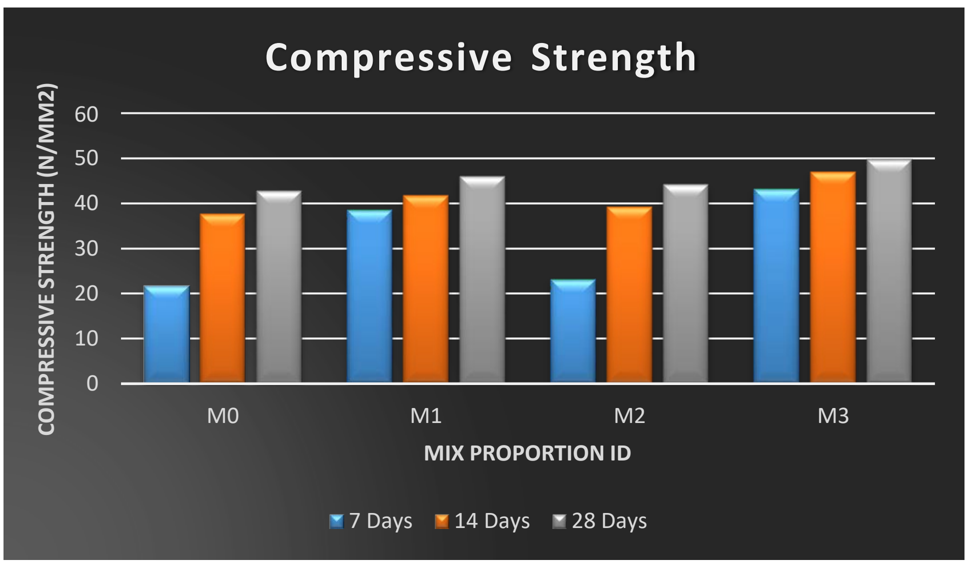

Fig: 1 Compressive Strength results

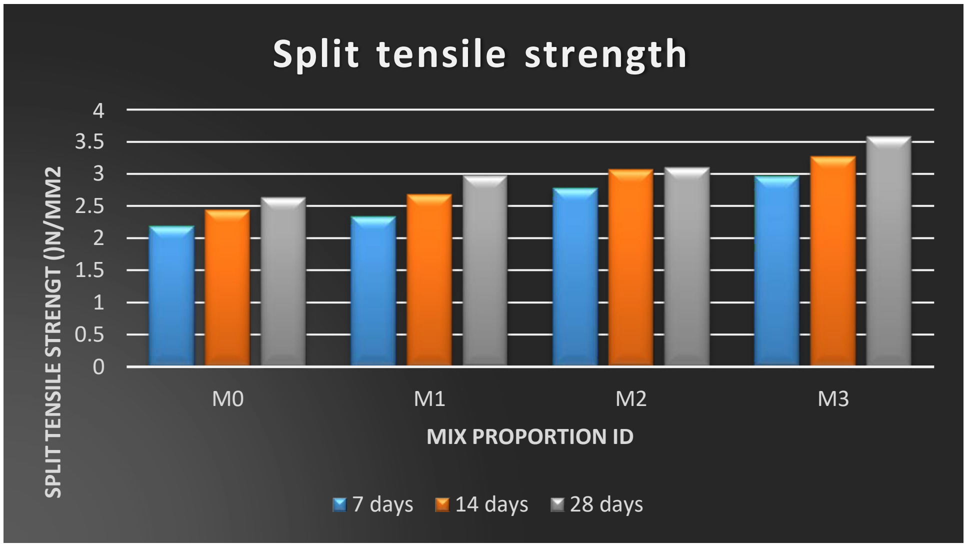

Fig: 2 Split Tensile Strength results

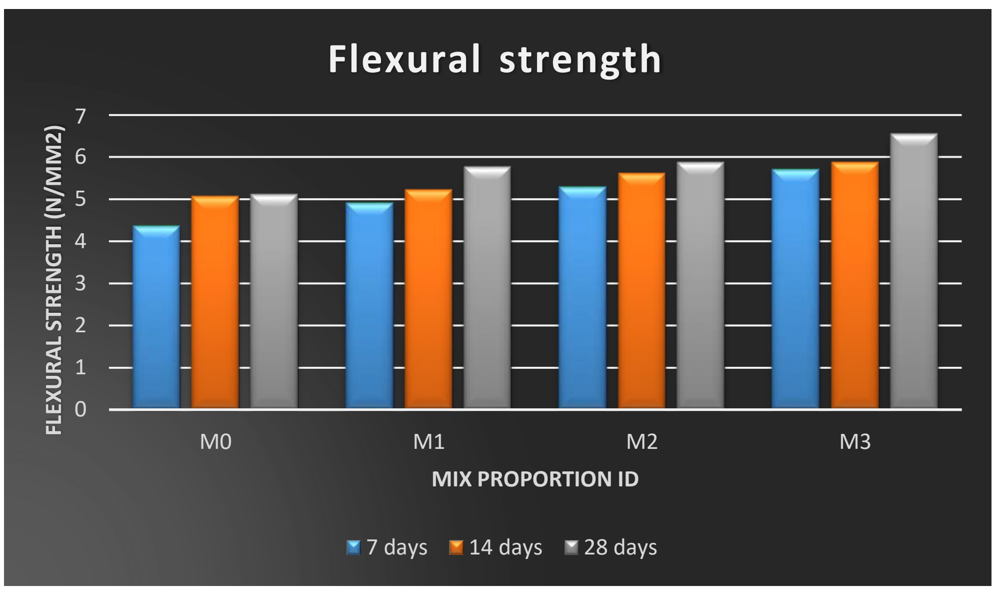

Fig: 3. Flexural Strength results

Conclusion

Based on the test results

The conclusion of the project work is

- The optimum fibre content is at 1.0% fibre content
- The compressive strength, split tensile strength and flexural strength of fibre reinforced concrete shows higher value than conventional concrete.
- The design of sisal fibre reinforced concrete proceeds from knowledge of basic properties under tensile, compression and flexural force, coupled with estimates

of behaviour under secondary loading effects such as creep, thermal and moisture movement.

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